ANALYSIS AND DESIGN OF COMBINATION OF FRACTAL ANTENNAS

A

Synopsis

Submitted for the degree of

DOCTOR OF PHILOSOPHY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

BY

PRADEEP KUMAR
09/LU/PHD/EC/03

Under the Guidance of

Dr. S. V. A. V. Prasad

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
LINGAYA'S UNIVERSITY, NACHAULI,
OLD FARIDABAD – JASANA ROAD,
FARIDABAD 121002, HARYANA, INDIA.

Outline of Proposed Research Work

Name of Scholar: Pradeep Kumar

Name of Guide: Dr. S.V.A.V. PRASAD

Title of research work: **ANALYSIS AND DESIGN OF COMBINATION OF FRACTAL ANTENNAS**

Location : Lingaya's University Faridabad

1. Objective of the research work:

Microstrip patch antennas are popular due to its inherent advantages of light weight, small volume, low cost, structural conformity and simplicity of fabrication. Low profile antennas support the operation of many modern communication systems. Microstrip patch antennas represent one family of compact antennas that offer a conformal nature and the capability of ready integration with a communication system's printed circuitry. The electrical and physical parameters of patch antenna are related differentially according to their electrical properties with respect to different frequencies. In fabrication of the microstrip patch antenna there are several parameters involve according to need, such as substrate material and their electrical and physical parameters such as dielectric constant, loss tangent, height and related parameter like effective dielectric constant, E and H beam width for particular frequencies.

The main objective of this thesis is the study of different configuration of microstrip patch antenna at different heights and frequency and design of an antenna with the combination of different fractal shapes. Design involved simulation, fabrication and measurements.

2. LITERATURE REVIEW

2.1 FRACTALS

Fractal geometries have found an intricate place in science as a representation of some of the unique geometrical features occurring in nature. Fractals are used to describe the branching of tree leaves and plants, the sparse filling of water vapour that forms clouds, the random erosion that carves mountain faces, the jaggedness of coastlines and bark, and many more examples in nature.

Euclidean structures have whole number dimensions, such as a one-dimensional line or a two dimensional plane. Benoit Mandelbrot first defined the term 'fractal' meaning fractional dimension in 1975 to handle geometries with dimensions that do not fall neatly into a whole number category . One property of a certain class of fractals is that it can have an infinite length while fitting in a finite volume.

Fractals, as used in this work, are structures of infinites complexity with a self-similar nature. What this means, is that as the structure is zoomed in upon, the structure repeats.

There never is a point where the fundamental building blocks are found. This is because the building blocks themselves have the same form as the original object with infinite complexity in each one.

Fractals can model nature very well. They can be used to generate realistic landscapes or sunsets, wire-frames of mountains, rough terrain, ripples on lake, coastline, seafloor topography and plants. Fractals can be divided into many types.

The idea of a dimension that is in between those of Euclidean geometries has opened by a new range for many applications, one of which being electromagnetic systems. It can be used to develop new configurations for radiators and reflectors. It might be possible to discover antennas that give us better performance than any Euclidean geometry could provide.

The general concepts of fractals can be applied to develop various antenna elements. Applying fractals to antenna elements allows for smaller, resonant antennas that are multiband and may be optimized for gain. The fact that most fractals have infinite complexity and detail can be used to reduce antenna size and develop low profile antennas.

When antenna elements or arrays are designed with the concept of self-similarity for most fractals, they can achieve multiple frequency bands because different parts of the antenna are similar to each other at different scales. Application of the fractional dimension of fractal structure leads to the gain optimization of wire antennas.

The combination of the infinite complexity and detail and the self-similarity makes it possible to design antennas with very wideband performance.

2.2 FRACTALS AS ANTENNAS

There has been an ever-growing demand, in both the military as well as the commercial sectors, for antenna designs that possess the following highly desirable attributes:

1. Compact size
2. Low profile
3. Conformal
4. Multi-band or broadband

There are a variety of approaches that have been developed over the years, which can be utilized to achieve one or more of these design objectives. Recently, the possibility of developing antenna designs that exploits in some way the properties of fractals to achieve these goals, at least in part, has attracted a lot of attention.

A wide variety of applications for fractals continue to be found in many branches of science and engineering. One such area is fractal electrodynamics, in which fractal geometry is combined with electromagnetic theory for the purpose of investigating a new class of radiation, propagation, and scattering problems. One of the most promising areas of fractal-electrodynamics research is in its application to antenna theory and design.

Traditional approaches to the analysis and design of antenna systems have their foundation in Euclidean geometry. There has been a considerable amount of recent interest, however, in the possibility of developing new types of antennas that employ fractal rather than Euclidean geometric concepts in their design. We refer to this new and rapidly growing field of research as fractal antenna engineering. Because fractal geometry is an extension of classical geometry, its recent introduction provides engineers with the unprecedented opportunity to explore a virtually limitless number of previously unavailable configurations for possible use in the development of new and innovative antenna designs. There are primarily two active areas of research in fractal antenna engineering. These include:

1.) The study of fractal-shaped antenna elements and
2.) The use of fractals in the design of antenna arrays.

3. Methodology:

Fractal Microstrip Patch Antennas will be designed by using IE3D software and simulation of this Antenna took place by using different combinations of fractal shapes, feeding techniques, and using slots either in Patch or ground. Here we can use different types of substrates in designing of an Antenna. Further in this designing of antenna will be carried out and its results will be compared with the Simulated designed Antenna.

4. Details of chapters of proposed research work:

The Antennas discussed here have many advantages over conventional antennas as these are easy to design and their better characteristics than the other antennas. These antennas find applications in aircraft, spacecraft, and satellite, missiles in wireless communication and even in handheld mobile telephones. Certain modifications have been done for better Antenna performance, like the use of parasitic elements, better impedance matching techniques, cavity-backed Antenna, electromagnetic coupling, photonic crystals and many more.

In the present Thesis commonly known Fractal Microstrip Patch Antenna (MSA) configurations will be discussed.

1. In the first chapter the introduction of Microstrip Patch Antenna will be discussed.
2. In second chapter we will include the literature review of fractals. In this we will discuss about the design, analysis and simulation results of various fractal structures.
3. In third chapter we will discuss about the Designing, Simulation, Fabrication and Characterization of various designs of fractal Microstrip Patch Antenna.
4. In fourth chapter, we will discuss about the Sierpinski type and Crown Square type fractal Microstrip Antenna. The results of the Sierpinski type and Crown Square type fractal Microstrip Antenna i.e. return loss, Gain, VSWR Plot, Co-cross Polarization shows effectiveness of the design antenna will be discussed. In this FR4 will be used as substrate.
5. In fifth chapter, two types of fractal Microstrip Patch Antenna designs will be combined and discussed. In this chapter three different combinations of fractals will be designed and their simulation results will be discussed.
6. In the Chapter sixth we will include a summary of the research undertaken for thesis, together with main conclusions. Suggestions for future work based on the findings of this thesis will be also included.

5. References:

[1] Bhattacharyya, A. K., and R. Garg, "Generalized Transmission Line Model for Microstrip Patches," *IEE Proc.*, Vol. 132, Pt. H, 1985, pp. 93-98.

[2] C.T.P. Song, Peter S. Hall and H. Ghafouri- Shiraz, "Perturbed Sierpinski multiband fractal antenna with improved feeding technique" *IEEE Transaction on antennas and propagation* , Vol. 51, No. 5, pp. 1011-1017, May 2003.

[3] S.Silver,"*Microwave Antenna Theory and Design*", McGRAW-HILL BOOK COMPANY, INC, New York 1949.

[4] C. A. Balanis, "*Antenna Theory, Analysis and Design*", JOHN WILEY & SONS, INC, New York 1997.

[5] K. F. Lee, Ed., *Advances in Microstrip and Printed Antennas*, John Wiley, 1997.

[6] Anzar Khan, Rajesh Nema, "Analysis of Five Different Dielectric Substrates on Microstrip Patch Antenna," *International Journal of Computer Applications* ISSN 0975 – 8887, Volume 55, No.18, October 2012.

[7] R. Garg, P. Bhartia, I. Bahl, A. Ittipiboon, "*Microstrip Antenna Design Handbook", ARTECH HOUSE,* Boston 2001.

[8] Steven R. Best "A discussion on the significance of geometry in determining the resonant behavior of fractal and other non-Euclidean wire antennas", *IEEE antennas and propagation magazine*, Vol. 45, No. 3, pp. 9 – 28, June 2003.

[9] Douglas H. Werner, "An overview of fractal antenna engineering research", *IEEE antennas and propagation magazine,* Vol. 45, No. 1, pp. 38 – 57, February 2003.

[10] John P. Gianvittorio and Yahya Rahmat-Samii, "Fractal antennas: A novel antenna miniaturization technique and applications", *IEEE antennas and propagation magazine*, Vol. 44, No. 1, pp. 20 – 36, February 2002.

[11]Nenad Hecimovic and Zdenko Marincic, "The improvement of the antenna parameters in ultra-wideband communications".

[12]Jerzy Guterman , Antonio A. Moreira and Custodio Peixeiro, " Microstrip fractal antennas for multistandard terminals" *IEEE antennas and wireless propagation letters*, Vol. 3, 2004.

[13]Carles Pueneta Barliarda, Carmen Borja, Monica Navarro Rodero, "An iterative model for fractal antennas: Application to the sierpinski gasket antenna" *IEEE Transaction on antennas and propagation* , Vol. 48, No. 5, pp. 713-719, May 2000.

[14]George F. Tsachtsiris, Constantine F. soras Manos P. Karaboikis "Analysis of a modified Sierpinski gasket monopole antenna printed on dual band wireless devices" *IEEE Transaction on antennas and propagation* , Vol. 52, No. 10, pp. 2571-2579, October 2004.

[15]Jordi Romeu and Jordi soler, "Generalized sierpinski fractal multiband antanna" *IEEE Transaction on antennas and propagation* , Vol. 49, No. 8, pp. 1237-1239, August 2001.

[16]Carles Pueneta-Baliarda,Jordi Romeu Rafael Pous, "On the behavior of the sierpinski multiband fractal antenna" *IEEE Transaction on antennas and propagation*, Vol. 46, No. 4, pp. 517-524, April 1998.

[17] Ansoft Designer, www.ansoft.com.

[18] IE3D Software Release 9 and developed by M/S Zeland Software, Inc.

[19]H. Gemmeke, "Radio detection of ultra high-energy cosmic ray air showers," in *Proc. Nuclear Science Symp. Conf. Rec.*, Oct. 23–29, 2005, vol. 2, pp. 1080–1083.

[20]S. El-Khamy, M. Mangoud, M. Aboul-Dahab, and A. Zaki, "Fractal multiband antennas using GA/MOM optimized log periodic dipole, arrays," in *Proc. IEEE APS Int. Symp.*, Jun. 20–25, 2004, vol. 4, pp.3433–3436.